Name:_____

AET Physics 2010, Practice Final Exam
Show all work. Turn off all cell phones.
Use 1130 ft/s for the speed of sound in air.

Multiple Choice (40 points): Circle the "best" answer. No need to show your work

Questions 1 & 2: A power line is 5 m long, and sways with a fundamental frequency of 3Hz. If the mass-per-unit length is 45g/m, what are…

1. (4 points) the speed of waves on the power line?
   a. 5 m/s
   b. 10 m/s
   c. 15 m/s
   d. 30 m/s
   e. None of the above
2. (4 points) the tension in the power line?
   a. 1.35 N
   b. 40.5 N
   c. 667 N
   d. 40,500 N
   e. None of the above

3. (4 points) The *first overtone* frequency of the 2.91 ft cardboard tube (which is closed at one end and open on the other) is…
   a. 54 Hz
   b. 97 Hz
   c. 123 Hz
   d. 242 Hz
   e. None of the above

Questions 4 & 5: All other things being equal, waves travels faster in…

4. (4 points) …thick strings or thin strings?
   a. thin strings
   b. thick strings
5. (4 points) …hot air or cold air?
   a. hot air
   b. cold air

Questions 6 & 7: A singer's voice has intensity 0.01 W/m^2 at the mic when she holds it 5cm away…

6. (4 points) What would be the intensity of the sound 15cm away?
   a. 10^{-4} W/m^2
   b. $1.1x10^{-4}$ W/m^2
   c. 1.1 mW/m^2
   d. 3.3 mW/m^2
   e. None of the above
7. (4 points) What is the difference in SIL between the sounds at 5cm and 15cm?
   a. 3 dB
   b. 6 dB
   c. 7.2 dB
   d. 12.1 dB
   e. None of the above

8. (4 points) The principle of superposition allows for
   a. Huygens principle
   b. Interference
   c. Fourier analysis
   d. All of the above
   e. None of the above

9. (4 points) A lecture hall has dimensions 50ft x 75 ft x 25 ft. According to the graph in the Berg & Stork textbook, what is the "ideal" reverb time?
   a. 0.1 s
   b. 0.35
   c. 0.5 s
   d. 0.75 s
   e. None of the above

10. (4 points) You have 6" to use as the air gap for a wood panel absorber which is to absorb at 90 Hz. What does the surface density of the panel need to be?
    a. 0.18 lbs/ft^2
    b. 0.31 lbs/ft^2
    c. 0.43 lbs/ft^2
    d. 0.59 lbs/ft^2
    e. None of the above

Short Answer (60 points): Answer on separate paper. *Use own words*, don't just copy from the book. Show your work for any relevant calculations.

11. (6 points) Describe the frequency spectrum associated with a "spike" or "pulse train". What are the implications of this for recording and reproducing (rapid) transient sounds?
    All harmonics have the same amplitude – the series does not converge. Thus, to accurately represent extremely rapid transients, an extremely high sample rate should be used.

12. (6 points) What is the "main physics reason" loudspeakers need to be mounted either in a wall or in some kind of enclosure?

    Because low freqeuncy waves can diffract around the back of the speaker; these waves will be 180^0 out of phase with waves coming off the front of the speaker. Thus these out-of-phase waves need to be blocked by some kind of enclosure or wall.

13. (8 points) To what must the decay variations in Everest Figure 11-8 be attributed?
Beats between closely-spaced modes

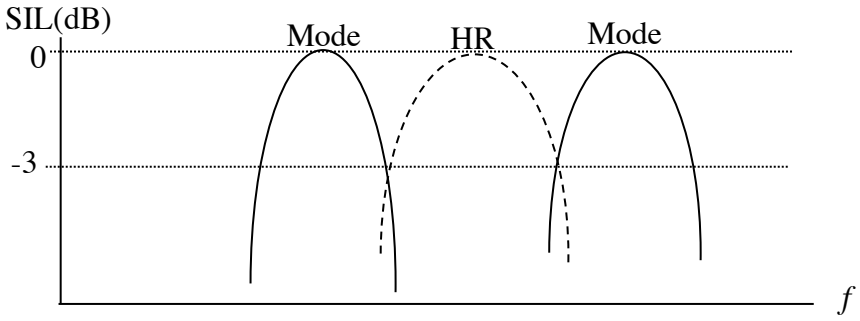
Problems 14 to 20 (40 points): You decide to turn your bedroom into a studio. The dimensions are 10ft x 15ft x 9ft. The floor is hardwood, with a Sabine absorption coefficient a = 0.3 Sab/ft^2. The walls and ceiling are plasterboard with a = 0.45 Sab/ft^2.

14. (6 points) What is the reverberation time?
    Answer: 0.21 s
15. (8 points) You decided to cover the walls & ceiling with a foam absorber, which will (for the purposes of this problem) *replace* the absorption coefficient of the plasterboard. If you want the new reverb time to be 0.15 s, what does the Sabine absorption coefficient of this foam need to be?
    Answer: 0.675 Sab/ft^2
~~16. (4 points) What energy absorption coefficient α does this correspond to?~~
~~17. (4 points) You set up a Tone-Burst experiment to research different foams. To have the coefficient found in the previous problem, how many dB should the difference be between the SIL of the reflected sound and the SIL of the direct sound?~~
18. (8 points) What are the lowest 4 (different) frequencies of modal resonances of the room?
    Answer:

nx	ny	nz	Freq. (Hz)
0	0	1	62.8
0	1	0	37.7
1	0	0	56.5
1	1	0	67.9

More anwers on next page!

You decide to try to "beef up" the response of your bedroom-studio between the two lowest resonant frequencies, by building a Helmholtz resonator (HR) to "span the gap" in the steady-state response of the room, as shown below. Say you want the -3dB points of the two modes and the HR to match up, like so:



19. (8 points) Say the reverberation time of the two modes is twice that of the room as a whole (which again is 0.15s). What is the reverberation time of your HR?

Answer:

The reverb time of the modes is 2*0.15 = 0.3s

The bandwidth of the two modes is $\Delta f = 2.2/T_R = 2.2/0.3 = 7.3$ Hz

The total range in Hz that needs to be covered is the difference between the two lowest mode frequencies, i.e. 56.5 – 37.7 = 18.8 Hz.

Thus the bandwidth needed by the HR is 18.8 – 7.3 Hz = 11.5 Hz.

The reverb time is 2.2 /11.5 = 0.19 s.

20. (2 points) Describe the effectiveness of the HR as far as your goal of "evening out" the room response between the two modes.

The reverb time of the HR is less than the RT60 of the Modes by .30 - .19 = 0.11s, so about a tenth of a second, and it's also of comparable length to the rest of the room (0.15s). This is probably an acceptable amount of variation.